Superior Systems for Every Need™

Silverstein™ Facial Nerve Monitor/Stimulator,

Model S8

Service Manual,

Version 2.1

WR MEDICAL ELECTRONICS CO.

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WR Medical Electronics Co.
123 North Second Street
Stillwater, MN 55082 USA
651-430-1200
FAX 651-439-9733
Toll-free 800-635-1312
Toll-free FAX 800-990-9733

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Memorize These Warnings Before Using This Instrument in the O.R.

ELECTROCAUTERY WARNING

- To avoid patient burns and damage to the unit, observe the electrocautery precautions in the operator's manual.
- Keep the ground electrode pads of the two units separated by at least 6 inches and keep the area between them free of electroconductive cream.
- Do not allow the cables of the electrocautery unit to be routed near the stimulator/monitor cables or sensor. Keep both sets of cables at least 6 inches apart.
- Never allow the electrocautery and stimulator probes to contact each other or simultaneously touch tissues or fluids in the surgical field.

OTHER WARNINGS AND CAUTIONS

- SENSOR INSTALLATION: Read and understand the section in this manual that describes proper installation of the cheek-muscle sensor.
- ALARM ARTIFACTS: Read and understand the section in this manual that covers alarm-artifacts, their causes and meaning. Monitor alarm may sound while output is being adjusted.
- SENSOR CARE & STERILIZATION: Read and understand the section in this manual that covers care of the sensor and sterilization guidelines. Do not steam sterilize the muscle sensor or the remote probe. Do not immerse in fluids.
- PARALYZING DRUGS: Read and understand the section in this manual on the effect of paralyzing drugs on nerve response.
- EXPLOSIVE GASES: This unit is not explosion proof. Do not use this instrument in the presence of explosive gases.
- BATTERY INDICATOR & RECHARGING: Check battery condition prior to and during use. The monitor and stimulator circuits each have their own independent battery supply. The monitor battery should be fully charged before use. For full battery capacity, charge for 36 hours before use, or leave plugged in when not in use. Yellow warning light illuminates when approximately 30 minutes to 120 minutes of battery power remains (depending on current-adjustment activity). Do not use instrument if FAIL light is illuminated. The stimulator battery will last approximately 50 hours, and must be replaced if the green light is out. Do not use the instrument without two positive green indications. Do not attempt to recharge the monitor battery while stimulating because the stimulus output display and output control circuit will be disabled.
- INSTRUMENT PERFORMANCE: Caution must be exercised since there is no guarantee that the monitor system will always respond to nerve stimulus. Current setting, distance from nerve, position and placement of sensor, muscle response and other factors will affect operation of the monitor. The monitor is designed to assist in locating nerves. No guarantee of performance is intended or implied.

- SERVICE & REPAIR: Because of the specialized circuitry of this instrument, the need for special test instruments, and our familiarity and experience with this instrument, we recommend that the instrument be returned to the factory for any necessary checking or servicing except routine battery replacement. See the Warranty, Service, and Loaner Program section of this manual for return instructions. This unit should be repaired only by qualified biomedical electronic technicians.
- GROUND ELECTRODE PLACEMENT: Do not place any stimulator ground electrodes on the chest or in close proximity to a pacemaker. Interference with the pacemaker could occur. If there is any uncertainty as to stimulator-pacemaker interference, do not use the stimulator on pacemaker patients.

INTRODUCTION

The SILVERSTEIN FACIAL NERVE STIMULATOR/MONITOR, Model S8, is a greatly enhanced version of the JAKO FACIAL NERVE MONITOR which has been in use since 1974. The methods of stimulation and monitoring have remained unchanged from the JAKO, and the intended use remains the same, but the Model S8 is much more sensitive and has additional controls to make operation of the instrument easier.

The Silverstein Facial Nerve Stimulator/Monitor, Model S8 uses adjustable, precisely controlled, low energy pulses to stimulate the facial nerve. A highly sensitive muscle movement sensor detects the resulting muscle movement in the cheek and generates an audible or visual signal. The muscle sensor is a clothespin shaped device which slides easily onto the patient's cheek. This allows detection of super-fine cheek contractions (often finer than can be felt with the nurse's hand) and allows drapes to remain over the face undisturbed.

Pulses (current measured in amperes) are delivered to the tissues using a pencil shaped probe. The current intensity can be accurately adjusted by the surgeon using push buttons on the probe. At very low settings, the nerve will respond only when direct contact with the nerve is made.

By probing the surgical site, and finding the lowest current which will elicit the least contraction, the surgeon can locate the Facial Nerve.

The Model S8 utilizes two separate circuits: one for monitoring and one for stimulating. These circuits may be used concurrently or separately.

The unit may be used as a stimulator only for plastic and reconstructive surgery, orthopedic surgery, or other procedures where visual or EMG confirmation of stimulus exists, or with the monitor for procedures involving the facial nerve.

FEATURES OF THE MODEL S8:

1. Ultra-sensitive muscle-movement sensor and circuitry. Often detects contractions finer than can be felt with the hand.
2. Sensitivity adjustment switch on front panel. Allows for varying degrees of sensitivity depending on requirements of the surgical procedure.
3. Convenient probe-mounted output control. Allows the surgeon to quickly adjust current as surgery proceeds, eliminating the need for additional personnel.
4. Easy to read lighted digital current display. Easily read from a distance in a darkened operating room.
5. Stimulus verification indicator. Monitors the integrity of all cable connections and verifies that proper current is being delivered.
6. Shatterproof case. Withstands accidental abuse.
7. High output audible alarm for high ambient sound level, with adjustable sound attenuator.
8. User selectable audible or visual signal.
9. Auxiliary panel jacks for bipolar forceps-type stimulator probes.

WARRANTY, SERVICE, AND LOANER PROGRAM

The Model S8 main unit is warranted to be free of defects in material and workmanship for a period of one year from purchase. The peripheral equipment is warranted for 90 days from date of purchase. Warranty is void if the unit has been damaged by electrocautery.

Service and technical questions are welcome. Because of the specialized circuitry of this instrument, the need for special test instruments, and our familiarity and experience with this instrument, we recommend that the instrument be returned to the factory for any necessary checking or servicing except routine battery replacement. This unit should be repaired only by qualified electronic technicians. To return a unit, ship the unit with its probes, sensor, and cables, via insured parcel post or insured UPS. Be sure to pack with plenty of padding to prevent damage during shipping.

Loaner units are available at no charge except for shipping, insurance, and any loaner supplies used.

STERILIZATION GUIDELINES

Gas sterilize only: Muscle Sensor
Remote Indicator Light
Remote Probe

Gas or Low Pressure Steam: Probe Tips
Indifferent Electrode (pad) Cable

The Sensor, Probes, and Cables should not be immersed in liquids, but may be wiped with cleansing agents. The cables should be carefully coiled to prevent tangling and kinking.

CURRENT CHARACTERISTICS

The Model S8 is safer than most constant-voltage or non-pulsed-DC stimulators because it delivers pulsed, constant current stimulation. To illustrate, the amount of energy transmitted to the patient is proportional to the amplitude of current (in milliamperes) and the duration of the pulse. Constant-voltage units can deliver excessive current, because these units automatically deliver an unlimited amount of current (subject to circuitry limitations) to meet the voltage chosen by the operator. In some cases this can damage nerve tissue. Likewise, non-pulsed-DC-stimulation may damage nerve tissue because they allow non-pulsed current to be transmitted through the nerve as long as the probe tip touches the nerve. The Model S8 allows stimulation to be applied directly on nerve tissue without risk of over stimulation.

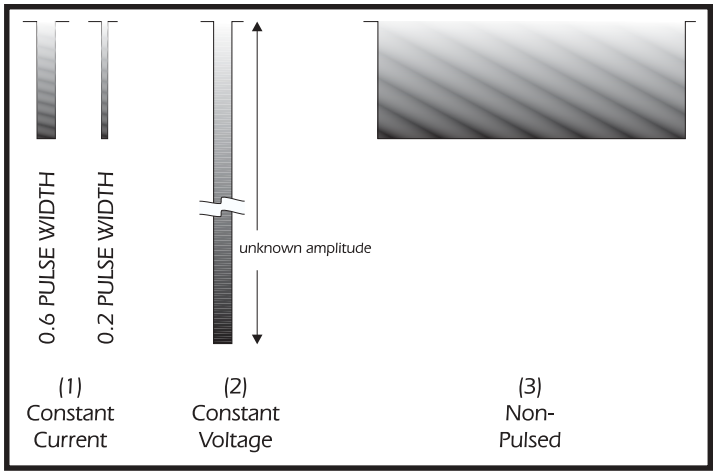


Figure 1

OUTPUT PARAMETERS

The Model S8 provides a square wave pulse which is adjustable from .05 mA (residual current) to 10.0 mA (maximum current) by means of the remote probe or a switch on the front panel. Current intensity refers to the amplitude of the individual pulses, not to the average level of current. Between pulses there is no current.

Nerve response to electrical stimulation is a function of current intensity through the nerve rather than of applied voltage. Consequently, precise control of current intensity is essential for quantitative evaluation of nerve response. In the Model S8, the voltage is automatically adjusted (utilizing a constant current output) to compensate for any differences or changes in the patient-stimulator circuit resistance so that the current is constant at any given setting of the current intensity display.

The pulse width is .0002 sec., with an off time of .1998 sec, for a total period of .200 sec. (The corresponding frequency is 5 pulses per second. There is a residual current of .05 mA when the display is at 0.)

The pulse width of .0002 seconds has been found to be optimal for subcutaneous (intraoperative) stimulation. For transcutaneous stimulation, a pulse width of .0006 seconds is required, due to the skin barrier. Stimulators with a .0006 second pulse width are available from WR Medical Electronics. Stimulators with a .0006 second pulse width may be used subcutaneously without ill effect but a .0002 second wave will not be effective transcutaneously.

PARALYZING DRUGS

A fairly high concentration of Xylocaine injected in close proximity to the facial nerve can reduce its responsiveness to the stimulating current and/or paralyze the nerve so that the muscle does not respond to electrical stimulation. However, it has been found that solutions containing one per cent or less of Xylocaine injected in normal quantity and not unduly close to the nerve do not appear to affect the function of the Model S8.

Succinylcholine can also cause muscle paralysis and prevent the facial muscles from contracting during stimulation.

PROCEDURES FOR USE WITH ELECTROCAUTERY UNITS

Procedures should be established to insure that the following precautions are taken:

- Keep the ground electrode pads of the electrocautery unit and stimulator unit separated by at least 6 inches and keep the area between them free of electroconductive cream.
- Do not allow the cables of the electrocautery unit to be routed near the stimulator/monitor cables or sensor. Keep both sets of cables at least 6 inches apart.
- Never allow the electrocautery probes, stimulator probes, or monitor sensors to contact each other or simultaneously touch tissues or fluids in the surgical field. Electrocautery voltages can damage the stimulator and monitor circuits, and cause a burn at the location of the indifferent electrode pad if the stimulator probes are allowed to touch the patient's tissues or fluids while electrocautery is energized.
- Alarm artifacts can also occur when electrocautery units are energized. Interference from electrosurgery is common with many monitoring instruments. The high energy of electrocautery units simply cannot be kept out of sensitive monitoring circuitry. The monitor has been deliberately

designed to be quite sensitive in order to respond to very small muscle response. This sensitivity can cause artifacts that are not a result of nerve stimulation. Patient movement and accidental contact with cables can also cause a monitor response. Operation of electrosurgery/cautery equipment may also cause a false response, depending on the equipment, cable and electrode arrangement and other unknown factors.

SENSITIVITY. THE SENSITIVITY SWITCH. AND ALARM ARTIFACTS

In position 1 the monitor is most sensitive. To desensitize turn the knob to numbers 2, 3, or 4.

This instrument is highly sensitive and has been designed to pick up the slightest vibrations and contractions of the cheek muscle. The sensitivity of the instrument is primarily determined by how the sensor is installed, and physiological factors of the patient. It is impossible to quantify how small of a contraction could be detected, but the instrument has the capability (under certain conditions) to pick up the expansion of tissue due to blood flow. This has been demonstrated in the lab and has been reported by surgical personnel. If you detect a blood pulse, turn the sensitivity down to the next level. Generally you will want to use the instrument on the most sensitive setting possible.

Alarm artifacts sometimes signify a problem and sometimes can be ignored. It is imperative that you learn their causes and meanings. Artifacts will be caused by the following:

- Movement of the drapes, operating table, or tubes near the face or in the mouth.
- Adjustment of the stimulus output current. The alarm will sound when the current is being adjusted on some or all sensitivity levels. This is a normal occurrence and does not indicate a fault with the unit. This occurs because the monitor is so sensitive it can detect the loss of electrons from the nickel cadmium battery pack (due to current draw by the motorpot).
- Energizing of electrocautery. Use the foot switch provided with the instrument to disable the alarm when electrocautery is energized. The LIGHT position may also be used. When locating nerves, be sure that interfering equipment is off.

Since the cheek can only contract as a result of nerve impulses, and since sensor only picks up contractions as a result of impulses (natural or artificial stimulation), most artifacts can be ignored with this exception:

In some cases the exposed nerve will spontaneously fire impulses when it is directly manipulated with a surgical instrument, bumped with a tool, or irrigated with cold fluids. If the spontaneous impulses are large enough, they will cause a contraction large enough to be detected by the sensor.

The sensitivity levels of each sensitivity-switch position (#1, 2, 3 and 4) can be checked and modified as outlined in the service manual. Settings should be set according to the latest standards issued by WR Medical Electronics.

SYSTEM COMPONENTS

The Silverstein Facial Nerve Stimulator/Monitor Model S8 Components:

- Remote Control Probe
- Pad (ground) Cable
- Remote Indicator Light
- Cheek-muscle Movement Sensor
- Foot Switch
- Set of 3 Snaps
- 7 Probe Tips:
  - Short Pointed
  - Short Blunt
  - Long Pointed Std
  - Long Pointed Medium
  - Long Pointed Fine
  - Long Blunt
  - Long Flush Tip
- Therasol Electrode Cream (4 oz. Bottle)
- Theratrode Disposable Electrode Pads (Pkg. of 10)
- Operator's Manual
- Service Manual
- Reference Papers
- Video Tape
- Electrocautery Warning

TESTING FOR STIMULUS OUTPUT: STIMULUS VERIFICATION

The unit may be tested for output by touching the active electrode to the ground pad. If the amber INCOMPLETE STIMULATION light goes out, the instrument is working properly.

The stimulus verification circuitry monitors the integrity of the patient/instrument circuit, including continuity of the probe and cable. When proper current is being delivered, the amber INCOMPLETE STIMULATION light will go out. It will flash at all other times - i.e. broken cables, disconnected cables, poor ground, poor probe contact, etc.

Verification of stimulation can also be obtained by touching the forearm or wrist area of a test subject, starting with a low current setting and increasing to a reasonable level (up to 6 or 8 mA may be required due to the narrow pulse width of .0002 sec.). Use a non-sterile probe for this procedure so that sterile probes will be available for surgery.

The unit may also be tested on an oscilloscope using a 1K precision resistor across the output. The oscilloscope will then display the pulse amplitude directly in milliamperes (1 volt = 1 mA).

The active probe can be shorted to the indifferent electrode without damage to the circuitry.

BATTERY CONDITION INDICATOR AND BATTERY CHARGING

WARNING: Check battery condition prior to and during use. The monitor and stimulator circuits each have their own independent battery supply. The monitor battery should be fully charged before use. For full battery capacity, charge for 36 hours before use, or leave plugged in when not in use. The yellow warning light will illuminate when approximately 30 minutes to 120 minutes of battery power remain (depending on current-adjustment activity). Do not use instrument if FAIL light is illuminated. The stimulator battery will last approximately 50 hours, and must be replaced if the green light is out. Do not use instrument without positive green indications.

To charge batteries, plug wall mount charger into 115-volt wall receptacle, and plug the small round connector into the back of the unit. The charge light should illuminate and will become dim as battery reaches fully charged level. The monitor and stimulator are disabled when the small battery charge connector is plugged in.

To replace the stimulator batteries, simply open the small door on the rear panel. Four size AA batteries will be found inside.

INSTALLING THE CHEEK MUSCLE MOVEMENT SENSOR

The cheek muscle movement sensor is inserted into the mouth and is attached to the cheek of the intubated patient on the same side as the intended surgical procedure. The side with the adjusting screw goes on the outside against the cheek. The blade inside the mouth should angle upward toward the eye between the gum and the oral mucous on the inside of the cheek. Bunch the cheek up in between the blades while pushing the sensor in tightly. The thumbscrew should be adjusted so the blades grasp the patient's cheek securely, with a light pressure. Excessive pressure may impair the response. The sensor may be secured to the cheek with strips of adhesive tape. After installing the sensor (but before draping the face), cover the eyes with eye protectors, and then cover the sensor with a hard surgical mask to prevent the drapes from impeding muscle movement and to prevent the drapes from brushing up against the sensor (which would cause alarm artifacts. The sensor wire should also be taped to the head.

Figure 2: Photograph showing hard surgical mask covering mouth sensor to prevent drapes from impeding muscle movement.

The plug on the end of the sensor cable is plugged into the SENSOR jack on the instrument panel. A sensor should be connected to the SENSOR jack at all times that the monitor is in use. If a sensor is not connected, the audible tone or light indicator may give false indication due to pickup of stray electrical noise or signals.

Each contraction of the cheek muscles causes a slight displacement of the white plastic blade on both sides of the cheek. The strain gages on the blades transmit an electrical signal which actuates the audible device on the instrument.

CHECKING THE SENSOR CIRCUIT

You may test the functioning of the monitoring circuit and audible signal by lightly touching the sensor. When the sensitivity switch is set to "1", the sensor will be so sensitive that if you set it on a flat surface and blow on it, you will set it off. You should be able to touch the patient's cheek lightly and get a response.

CARE OF THE SENSOR

The sensor is quite delicate and should be treated with care. Pulling on wires, repeated bending, especially sharp bends, can cause broken wires or intermittent false signals. The sensor does not need to be sterilized because the patient's mouth is not a sterile field. The sensor may be cleaned by wiping with cold cleaning or sterilizing solutions and may be gas autoclaved. It must not be immersed in cleaning solutions and must not be steam autoclaved because such procedures will draw moisture into the sensor and the cable, causing corrosion and malfunctioning of the instrument.

THE REMOTE PROBE

The Remote Probe accepts seven interchangeable tips to meet different needs. The long tips are insulated so they will not short out against the edge of the incision. The tip is secured in the probe chuck by tightening the chuck nut. The remote probe has two buttons for controlling current output. The front button is up, the rear button is down. To connect the remote probe to the front panel, align connectors, insert plug, and rotate locking collar on plug. Never simultaneously press both up and down buttons.

AUX STIMULATOR JACKS

Any standard bipolar forceps type probe can be used. Current can be controlled using either the remote probe, or the switch on the front panel. If the remote probe is used to control current, use caution as the tip is "active" whenever it is plugged in. The AUX binding posts accept banana plugs, spade lugs, alligator clips, or bare wire. Either plug can be connected to either AUX jack. Shorting the probe tips or AUX jacks together will not harm the instrument. No reference electrode is required when a bipolar stimulating probe is used. Surgical instruments having a black non-reflective coating are not suitable for applying the stimulating current because of the high electrical resistance of the coating.

PAD (GROUND) CABLE

When a unipolar probe is used, (either the Remote Probe or a customized probe), a (ground) Pad must be used to complete the electrical path through the patient.

SKIN PREPARATION

An indifferent electrode pad, also called a ground pad, applied to the skin outside the sterile field completes the stimulator circuit through the patient. Use WR Medical THERATRODE or new self-adhesive THERATRODE II for best results. If using the THERATRODE pad, and to minimize the electrical resistance between the electrode and skin, the fabric layer of the pad must be thoroughly saturated with THERASOL electroconductive cream so that the cream reaches the underlying layer of foil. A small amount of the electrode cream should also be massaged into the skin to break down the natural skin oils and reduce the electrical resistance. THERASOL cream readily soaks through the fabric layer, but electroconductivity gels may not penetrate the fabric and will not assure good electrical contact.

The purpose of the fabric layer is to retain the THERASOL electrode cream and maintain good conductivity during long surgical procedures. The THERATRODE pad is disposable and if it is reused, the solids from previous applications of THERASOL cream will retard penetration of the cream and cause excessive resistance.

When the patient is being prepared for surgery, apply the THERATRODE electrode pad saturated with THERASOL cream in an appropriate area outside the sterile field underneath the drapes and secure it with adhesive tape. Attach one end of the Pad (ground) cable to the snap connector on the pad, allowing the other end to extend from beneath the drapes for later connection to the unit.

PULSE LIGHT

When instrument is on, the clear PULSE light flashes with each pulse of the stimulating current, indicating that the instrument is on and that the stimulator section is functioning. Between stimulating or monitoring activity, turn the instrument off to conserve battery power.

HORN/LIGHT SWITCH

The HORN/LIGHT switch is used to select aural or visual signal, at the option of the surgeon. In cases where other patient alarms have a similar aural signal, or where the operating environment may be too noisy to hear the audible tone, the visual signal may be selected.

An extra loud audio signal has been provided for procedures where other surgical equipment may generate substantial sound levels.

The sound level may be easily reduced to a comfortable level by adjusting the sound attenuator on the face of the horn.

USE OF THE REMOTE LIGHT

With the HORN/LIGHT switch in the LIGHT position, the REMOTE INDICATOR LIGHT (if plugged in) will activate at the same time as the red panel light. The REMOTE INDICATOR LIGHT may be placed in a position convenient to the surgeon's or other staffs field of vision. This is useful where the monitor, which is placed outside the surgical field, cannot be readily viewed.

TILT STAND

The tilt stand can be rotated to the rear of the instrument to allow placement on a stack of monitoring equipment. To rotate, pull both stand hubs out simultaneously and rotate underneath the instrument.

GENERAL THEORY OF NERVE STIMULATION

Electrical stimulation of a nerve or nerve branch evokes contractions of associated muscles, affording a visual confirmation of the response to the stimulation. A certain minimum level of current intensity through the nerve tissue is required to reach the stimulation threshold and produce minimal muscle contractions. As the current is increased above this level, the contractions become progressively stronger until the point at which the entire muscle is responding fully.

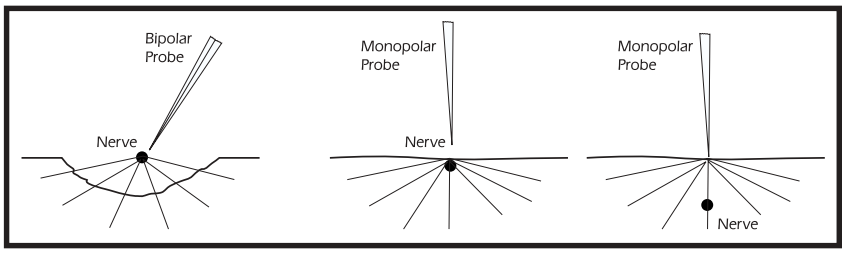


Figure 3: Probe applied to nerve

When a stimulating current is applied directly to an exposed nerve, figure 3, virtually the entire current flows through the nerve tissue, consequently the muscle response occurs at a relatively low current setting. When the current is applied at a point remote from the nerve, the current flow is diffused through the tissues and only a portion of the applied current actually reaches the nerve. Inasmuch as the muscle response is a function of current intensity through the nerve, a higher level of current is required to evoke a given muscle response than when the current is applied directly to the exposed nerve. The current level required for a given response is generally proportional to the square of the distance between the nerve and the point at which the current is applied.

It is not possible to set forth a definite numerical relationship between current setting and distance in millimeters from the nerve. Rather, the current settings must be considered as indicating relative distances as you work progressively closer to the nerve during a given procedure. When the signal sounds at a relatively low current setting, it indicates that the surgical instrument is correspondingly close to the nerve. With experience, the user will be able to relate current settings to approximate distances from the nerve.

Silverstein has found that 1 mm bone needs approximately 1 milliampere of current to stimulate the facial nerve.

It should be noted that the relationship between current intensity and distance is nonlinear as shown graphically in figure 4, and a given increment of current intensity does not correspond to a fixed increment of distance. In close proximity to the nerve, a given increment of distance (Δd) corresponds to a smaller increment of current intensity (ΔI) than at greater distances from the nerve (ΔI).

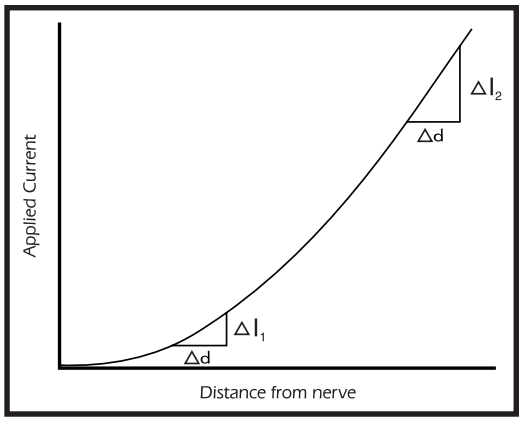


Figure 4: General relationship between applied current and distance from nerve.

During surgery, the lowest possible current should be used, especially in a wet field close to nerves. With the bipolar probe on a nerve, a fraction of a milliampere should be sufficient. With the unipolar probe, high current settings will cause nerve and muscle response at a greater distance from the nerves.

FINDING A NERVE UNDERLYING OTHER TISSUE

The selected probe is applied to the tissue bed overlying the nerve, and the current intensity is turned up until muscle contractions are observed. The probe is then applied at intervals along a line at right angles to the general course of the nerve. At each point, the current intensity is readjusted to the minimum level which will produce muscle contractions, and the current reading is noted. The successive current readings will vary depending upon the square of the distance between the probe tip and the nerve. The nerve underlies the point at which muscle contractions occur with the lowest current setting.

INDICATING PROXIMITY OF A NERVE

At the beginning of the surgical procedure, while the exposed tissues are still a good distance from the nerve, turn the current up high enough to cause muscle contractions and sound the signal. This will verify that the instrument is functioning properly and will establish as a reference the current intensity corresponding to the initial distance from the nerve. Then turn the current down until the signal stops sounding. As you dissect the overlying tissues and get closer to the nerve, you will provide sufficient intensity through the nerve to evoke contractions and sound the signal.

As you continue the dissection, turn the current to successively lower levels to sound the signal at correspondingly shorter distances from the nerve. Experience with the instrument enables the surgeon to relate the current settings required to evoke contractions to the corresponding distances from the nerve.

It must be borne in mind that as you approach a nerve, a given change in current setting corresponds to progressively smaller increments of distance. When a current setting of about 0.2 mA actuates the signal, it indicates that the nerve is quite close.

If the signal does not sound after further dissection of the tissue has brought you significantly closer to the nerve, turn the current setting back up enough to actuate the signal. This assures that the system is functioning and provides a new reference point with respect to current setting.

CAUTION: Sounding of the signal indicates that the nerve is within the relative distance corresponding to the current setting. Absence of the audible signal should not however be construed as assurance that the nerve is beyond the distance corresponding to the current setting. The usual caution must be used in approaching the nerve, even though the current setting may indicate that it is still a safe distance away. Normal precautions must be taken to see that the lead wires do not become disconnected from the instruments or from the output receptacles. If a particular lead wire should be disconnected, the signal would not sound regardless of the proximity of that instrument to the nerve.

NERVE IDENTIFICATION

In differentiating a nerve from fibrous tissue, the current intensity should be set at the minimum level which will evoke muscle contractions with the probe applied directly to the nerve. When the probe is applied to other tissues at this same setting, there should be no response. If the current is set too high, the nerve may be stimulated when the probe is applied to other tissues and the test will not differentiate the nerve.

In differentiating two nerves or nerve branches in close proximity, the stimulating current is applied to each in turn and the differential muscle response is observed. It is essential that the current intensity be set low enough to stimulate only the nerve to which the probe is applied. Too high a current could stimulate both nerves simultaneously.

NERVE EVALUATION

When greater-than-threshold electrical stimulation is applied to an exposed nerve, the presence or absence of muscle contractions indicates the viability of the nerve.

Stimulation of the exposed facial nerve with currents of .05 to .2 mA will indicate normal facial function postoperatively.

1.0 MAINTENANCE INTRODUCTION

This section of the manual covers the Silverstein Facial Nerve Stimulator/Monitor model S8 periodic maintenance and checkout procedures. If you experience problems with your unit contact WR Medical Electronics Technical Service Hotline. Because of specialized circuitry only qualified biomedical personnel should attempt to repair the Silverstein Facial Nerve Stimulator/Monitor model S8.

1.1A OUTPUT/INPUT PARAMETERS

STIMULATOR

The Silverstein Nerve Stimulator/Monitor model S8 provides a square wave pulse which is adjustable from .05 mA (residual current) to 10 mA (maximum current) by means of a remote probe or a switch on the front panel. Current intensity refers to the amplitude of the individual pulses, not the average level of current. Between pulses there is no current. The pulse width is .0002 seconds, with an off time of .1998 seconds. There is a residual current of .05 mA when the digital display is at 0. Nerve response to electrical stimulation is a function of current intensity through the nerve rather than of applied voltage. Consequently, precise control of current intensity is essential for quantitative evaluation of nerve response. In the Silverstein S8, the voltage is automatically adjusted (utilizing a constant current output) to compensate for any differences or changes in the patient/stimulator circuit resistance so that the current is constant at any given setting of the current intensity display.

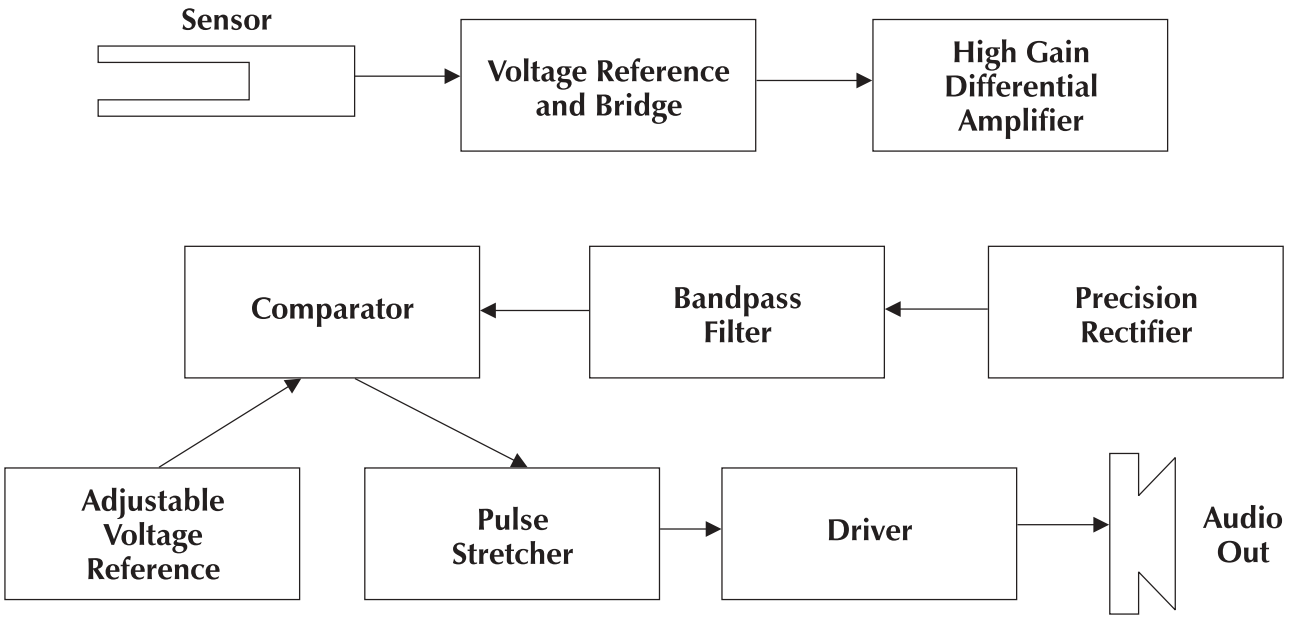
MONITOR

The Silverstein Nerve Stimulator/Monitor model S8 is very sensitive. It utilizes a high gain differential amplifier in conjunction with a mechanical strain gage muscle movement sensor to detect contractions of the cheek muscle when the Facial nerve is stimulated. The signal is then processed and presented in the form of an audio alarm beep or the flash of an indicator light. The sensitivity of the monitor is controlled by the sensitivity switch on the front panel. Sensitivity position 1 is the most sensitive and position 4 is the least sensitive. The unit can be muted with the use of the foot switch.

1.1B TECHNICAL SPECIFICATIONS:

Stimulator Current Output:	0 to 10 mA, residual .05 mA at 0 indicated.	
Pulse Width:	.02 Msec	
Pulse Frequency:	200 Msec (5 Hz)	
Dial Accuracy:	Linear down to .15 mA, residual current of .05 mA at 0 indicated.	
Batteries:	Two 8.4 volt, 2.2 AH nickel cadmium packs. Four 1.5 volt AA alkaline batteries.	
Monitor Battery Life:	11 hours continuous use when fully charged. Charge after each use, and once a month. Replace nickel cadmium pack once a year	
Stimulator Battery Life:	300 hours, replace when stimulator battery fail indicator light illuminates.	
Case Size:	8x5x9 inches (21 x 13 x 23 cm)	
Current Characteristics:	Constant pulsed current stimulation. Accurate delivery from 0 - 10K ohm load at 1 mA typical.	
Sterilization Guidelines:	Gas only:	Remote Probe
		Muscle Sensor
		Remote Indicator Light
	Steam/Gas:	Pad (Ground) Cable
		Probe Tips

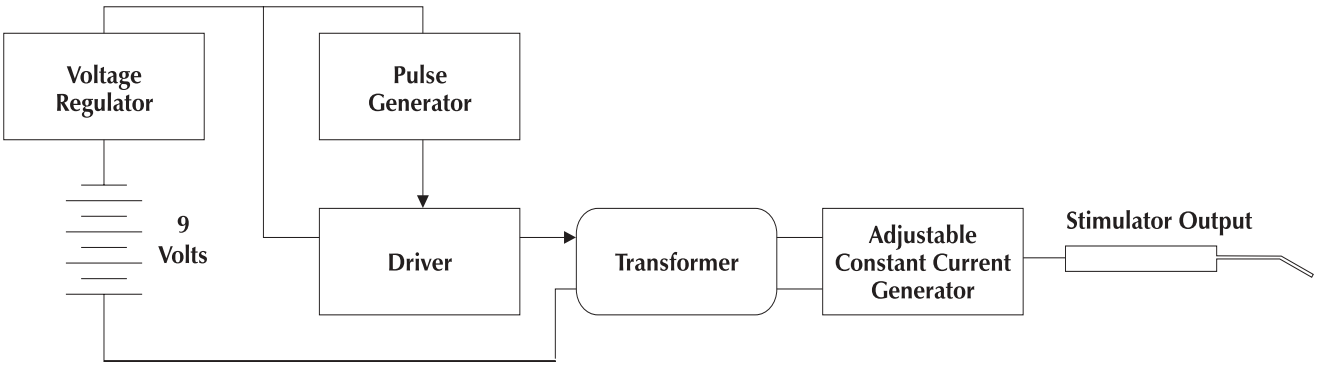
1.2A MONITOR BLOCK DIAGRAM:



1.2B MONITOR BLOCK DIAGRAM DESCRIPTION:

- Dual Strain Gauge Sensor: Clip type muscle movement sensor is clamped to the facial muscle. Consists of two strain gauges located on the upper blade of the sensor. The gauge differentially detects changes in pressure of the facial muscle.
- Voltage Reference and Bridge: A 5 volt reference and bridge is used to put current through the differential strain gauges. Changes in pressure yield a small change in voltage.
- Hi Gain Differential Amplifier: A high gain differential amplifier (Gain X 500) is used to amplify the differential voltage.
- Precision Rectifier: Detects zero crossing points and converts signals to pulsed DC signals.
- Bandpass Filter: 10 - 200 Hz twin T bandpass filter. Removes DC component, and filters out electrical noise.
- Adjustable Voltage Reference: The user may select 4 sensitivity levels which are represented by 4 discrete voltage references which are used by the signal comparator.
- Comparator: Detects peaks of input pressure signal and compares them with input reference signals. If a peak is higher than the reference signal the output is transmitted to the Pulse Stretcher.
- Pulse Stretcher: Converts detected peak into 1 second 5 volt pulse that then triggers the audio/ visual alarm.
- Driver and Alarm: Drives LED indicator and Sonalert audio alarm.

1.3A STIMULATOR BLOCK DIAGRAM:



1.3B STIMULATOR BLOCK DIAGRAM DESCRIPTION:

- Voltage Regulator: Supplies a constant 3.8 volts for the pulse generator and primary driver.
- Pulse Generator: Generates stimulator pulse train at specified frequency and width.
- Driver: Switches 9 volts pulse into 100 volt pulse.
- Adjustable Constant Current Generator: Stimulation current is user adjustable via switches on the surgical probe. Relays drive a motorpot assembly which sets the output current level. The constant current pulse is then generated by measuring the voltage drop across an internal load and varying the output voltage as needed. If the voltage drop is too small, the incomplete stimulation light flashes to warn the operator that excess resistance exists.

2.0 MAINTENANCE SCHEDULE

Detailed maintenance procedures are in sections 3 and 4.

2.1 THE FOLLOWING ACTIONS MUST BE TAKEN AFTER EACH USE:

1. Sterilize equipment.
2. Recharge monitor batteries
3. Check stimulator batteries and replace if necessary.
4. Check front panel controls.

2.2 THE FOLLOWING ACTIONS MUST BE TAKEN EVERY THREE MONTHS:

1. Check monitor calibration.
2. Check stimulator calibration.
3. Replace stimulator batteries.
4. Clean the exterior with a water damp cloth.

2.3 THE FOLLOWING ACTIONS MUST BE TAKEN EVERY YEAR:

1. Unit should be returned to WR Medical Electronics every year for routine calibration.
2. Replace Nickel cadmium monitor batteries.

3.0 MAINTENANCE PROCEDURES

Maintenance procedures in sections 3.2 through 3.6 must be done only when the instrument case is closed. If calibration procedures are going to be preformed, complete section 4 and then follow the maintenance procedures in section 3.2 through 3.6 for the final checkout.

3.1 STERILIZATION GUIDELINES:

1. The Remote Probe, Remote Indicator Light, and the Muscle Movement Sensor must be gas sterilized only.

   WARNING: Steam sterilization will cause corrosion and discoloration of the Silverstein S8 peripheral equipment, and possible malfunction may occur. Only the probe tips and the Indifferent Electrode (PAD) Cable can be steam sterilized.

3.2 MONITOR BATTERY RECHARGE:

Equipment Needed:

1. WR wall-mount battery charger.

Setup:

1. Turn unit off. Unit will not charge when unit is on.
2. Plug wall mount charger into 115-volt wall receptacle.
3. Plug the wall mount charger connector into the charger jack on the rear of the unit.

   WARNING: Do not attempt to recharge the monitor battery while stimulating or monitoring. The unit will only charge when the unit is off.

Procedure:

1. The charge light should illuminate when the charger is plugged in and the unit is turned off. For full battery capacity, charge the unit for 36 hours, or leave the unit plugged in when not in use.
2. When the unit is turned on, the green monitor “Battery Good” indicator should illuminate, this indicates adequate charge is present. Do not use instrument without the green “Battery Good” indicator illuminated. The yellow “Battery Charge” indicator illuminates when there is approximately 30 minutes of battery power remaining.

3.3 STIMULATOR BATTERY CHECK:

Equipment needed: none

Set up: none

Procedure:

1. Check the red and green stimulator battery indicators for the battery condition. A green indication indicates adequate power remains. A red indicator indicates that the stimulator batteries must be replaced.

   WARNING: Check the stimulator battery condition prior to and during use. The stimulator will function for about 10 hours once the red stimulator “Battery Fail” indicator illuminates. Replace the batteries as soon as possible when the red “Battery Fail” indicator illuminates.

3.4 VISUAL INSPECTION:

Equipment: none

Setup: none

Procedure:

1. Check knobs for tight fit.
2. Check indicator lights for proper indication with no peripheral equipment plugged into the unit:
    a. Digital Display Illuminated.
    b. Monitor “Battery Good” indicator illuminated.
    c. Stimulator “Battery Fail” indicator off.
    d. Stimulator Pulse and Incomplete Stimulation Lights flashing.
3. Check the charge circuit by turning the unit off and plugging the WR wall mount battery charger into the 115-volt wall outlet and the power plug into the rear of the unit. The red “Battery Charge” indicator should illuminate.
4. Check the electrocautery mute foot switch for nicks and cuts in the cable or other obvious physical damage. Check the plug for proper fit into the foot switch jack on the instrument.

3.5 SENSOR, AUDIO ALARM, AND FOOTSWITCH:

Equipment:

- Silverstein Facial Nerve Monitor/Stimulator Model S8
- Cheek Muscle Movement Sensor
- Foot Switch
- VOM

3.5A CHEEK MUSCLE MOVEMENT SENSOR:

1. Unplug the sensor from the unit.
2. Attach one ohm meter probe to the center conductor on the plug end of the sensor. Attach the remaining ohm meter probe to the opposite side of one of the two strain gages see figure 8. Approximately 350 ohms should be obtained.
3. Flex the ends of the protruding blades together and then apart 1/8", CAUTION: over flexing the blade may cause damage to the sensor. If any shorts or open circuits are detected the sensor must be repaired or replaced.
4. Place the ohm meter probe located on the outer plug pin on the remaining plug pin with a strain gage attached. 350 ohms should be obtained. See figure 9 Repeat step 3.5a #3.

3.5B AUDIO ALARM AND FOOT SWITCH:

1. Plug the Cheek Muscle Movement Sensor into front panel sensor jack.
2. Plug the foot switch into the foot switch jack.
3. Turn the sensitivity switch to setting 1.
4. Turn the unit on.

5. Tap on the top sensor blade lightly (the top blade has a thumb screw) the audio alarm should sound.
6. Repeat steps 1-5 for sensitivity settings 2, 3, and 4.
7. While taping on the sensor lightly to evoke the audio alarm step on the foot switch. No audible response should be evoked.
8. If audible alarm does not cease when you step on the foot switch while taping on the sensor, check the foot switch with an ohm meter for continuity when the foot switch is at rest. Also check for infinite resistance when the switch is stepped on. If fault cannot be found, return complete unit to WR Medical Electronics for repair.

3.6 STIMULATOR CALIBRATION CHECK:

Procedures in section 3.6a through 3.6f are to be done without opening the unit enclosure.

3.6A STIMULATOR AA BATTERY PACK CURRENT DRAW:

This step checks the circuit board and wiring to be sure that excessive current is not being drawn from the stimulator AA battery pack.

Equipment Needed:

1. Power supply
2. VOM meter.

Setup:

1. Open the small gray door on the rear of the unit.
2. Disconnect the AA battery pack.
3. Set the power supply to zero (0) volts.
4. Turn the power supply off.

Procedure:

1. With the Silverstein S8 power switch in the off position, observe polarity and connect wires from the power supply to the stimulator battery connector with an in-line Ammeter.
2. Turn the unit on and slowly bring the power supply voltage up to 4.75 volts. The current draw should equal approximately 20 mA at 4.75 volts.

If the stimulator current draw exceeds 30 mA return unit to WR Medical Electronics for repair.

3.6B LCD CURRENT INTENSITY DISPLAY DRIFT CHECK:

Procedure:

1. Turn unit on.
2. After 10 seconds the numbers on the display should be stable.
3. Increase and decrease the stimulator current intensity and let the digital panel display stabilize for a short time. The display should not drift.

If display drifts, return to WR Medical Electronics for repair.

3.6C REMOTE PROBE, PAD JACK, AUX/GROUND JACK CHECK:

The remote probe is used to change the stimulator current intensity, and acts as the active stimulating electrode.

Equipment:

1. Remote Probe
2. Probe tip
3. Jumper wire

Setup:

1. Insert a probe tip into the chuck on the remote probe
2. Plug the remote probe into the probe jack.

Procedure:

1. Turn the unit on. The pulse light and the Incomplete Stimulation Light should be flashing.
2. Touch the end of the probe (with a tip inserted) to the PAD jack and then to the GND jack. The Incomplete Stimulation Light should go out, indicating a complete electrical path.
3. Push the remote probe switch button nearest the probe tip. The current intensity should increase. When pushing the switch button on the cord end, the current intensity should decrease.
4. Disconnect the probe from the unit. Attach a jumper wire between the active and GND jack; the incomplete stimulation should go out indicating a complete electrical path.

If malfunctioning, return to WR Medical Electronics for repair.

3.6D STIMULATOR PULSE WIDTH, FREQUENCY, AND AMPLITUDE CHECK:

Current intensity in this section refers to stimulator pulse amplitude in milliamperes. Pulse amplitude is measured with a 1K resistor across the output of the instrument. The voltage drop across the resistor is displayed on the scope. In accordance with Ohm's law the scope measures the amplitude directly in milliamperes (1 volt = 1 mA).

The Active jack corresponds to the active electrode and is connected to the positive (+) scope terminal. The stimulator GND jack is connected to the negative (-) scope terminal. A 1K 1/4W resistor is placed across the jacks. See figure 5 for setup.

The output pulses are negative going on the scope. See figures 1, 6, and 7 for description of waveform.

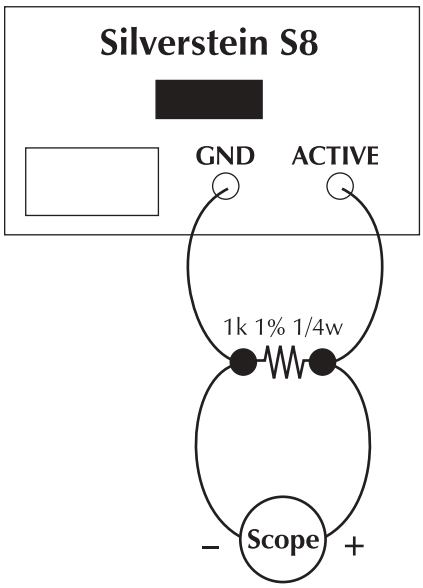


Figure 5

Equipment:

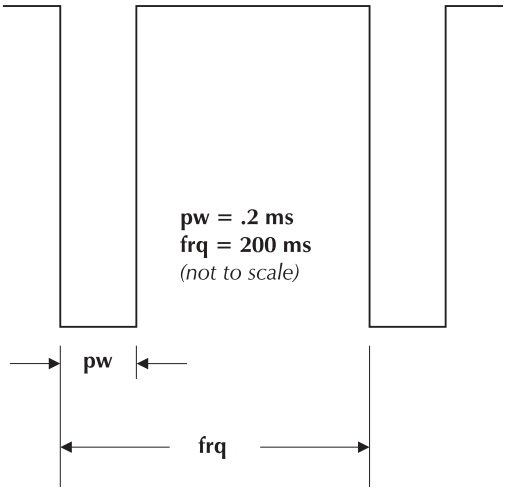
1. Oscilloscope
2. IK 1/4 watt resistor

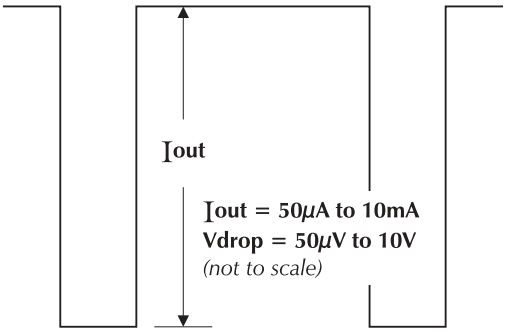
Setup:

1. Set the scope sweep to .1 milliseconds/division, sensitivity to 10.0 millivolts/division, DC coupled, slope to negative (-).
2. Set the current intensity display on the Silverstein S8 to 0.00 mA.

Procedure:

1. To Check the Stimulator Bias Current and Gain:
   - Check the bias (current intensity display at 0.00) for 50 microamps or 50 millivolts displayed on the scope. Check the current gain by adjusting the scope to 2 volts/division and changing the unit's current intensity to 10 milliamps. By ohms law, 10 volts dropped across a 1K resistance equals 10 milliamps (E=I/R).
2. To Check the Stimulator Pulse Frequency:
   - Set the scope sensitivity at 2 volts/division, sweep at 20 milliseconds/div and align the triggered pulse precisely on the grid line on the far left side of the screen. Check the frequency for 200 milliseconds.





Figures 6 (top) and 7

3. To Check the Stimulator Pulse Width:
   - Reset the sweep to 0.1 milliseconds/division and check for a pulse width of 0.2 milliseconds.

     If unit is out of calibration, return to WR Medical Electronics for calibration.

3.6E STIMULATOR OUTPUT LINEARITY AND EXCESS RESISTANCE LIGHT TEST:

Equipment: Same as in step 3.6d.

Setup:

1. Scope sweep at .1 milliseconds/division, sensitivity to 2 volts/division, DC coupled, slope at negative (-).
2. Set current intensity display on the Silverstein S8 to 10.00 milliamps.

PART A

Procedure:

1. Disconnect the stimulator output load (IK ohm). The excess resistance light should flash.
2. Reattach the IK load.
3. Adjust the current intensity display down from 10 milliamps progressively to settings of 6.0, 3.0, and 0.0 milliamps, checking the pulse amplitude on the scope against the current intensity display to verify linearity.

4. Test the excess resistance light operation at 6.0, 3.0, and 0.0 milliamps by disconnecting the IK resistor from the output. When the IK load is removed the Incomplete Stimulation light should flash.

PART B

Description: When the stimulator load resistance is too great to supply constant current, the Incomplete Stimulation light will flash.

Equipment:

1. Oscilloscope
2. 1K 1/4W resistor
3. 100K variable resistor

Setup (See Figure 8):

1. Connect a 1K 1/4 W resistor and a 100K variable resistor in series across the stimulator output.
2. Set the variable resistor at 0 ohms.
3. Attach the scope output across the IK resistor.
4. Set the scope sensitivity to 1 volt/division, sweep at 0.1 milliseconds/division, DC coupled, and the slope to negative (-).
5. Adjust the current intensity to 5.50 milliamps.

Procedure:

1. Adjust the 100K variable resistor upwards until it brings the pulse amplitude on the scope back down to 5 milliamps (5 volts displayed on the scope).
2. Adjust the current intensity down below 5.0 milliamps, and then adjust it back to 5.0 and above. Up to a setting of 5.0 milliamps, the current intensity should increase. But above 5.0 milliamps the current should not increase.
3. The incomplete stimulation light should come on between 4.5 and 5.2 milliamps.

If any problems are found in section 3, return complete unit to WR Medical Electronics for repair. If you are qualified and choose to perform Calibration procedures yourself, please follow section 4. If the unit is opened, section 3 must be repeated after the enclosure is closed. This helps assure safe and reliable operation.

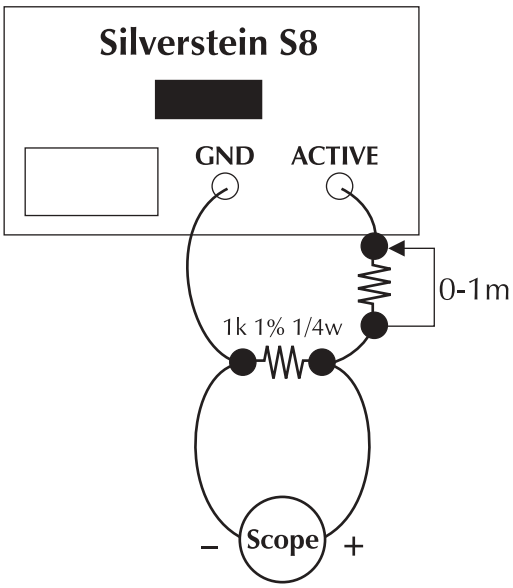


Figure 8

4.0 CALIBRATION PROCEDURES

WR Medical Electronics recommends contacting there Technical Service Department with the unit serial number before attempting Calibration procedures. The Dept. can check on any recommended modifications for your unit. After completing section 4, refer to section 3 for a final check out with the case closed. In section 4 the case must be opened to recalibrate settings.

4.1 POWER UP:

The monitor section of the Silverstein runs on two nickel cadmium battery packs located in a battery case (black) inside of the main enclosure. To access the nickel cadmium battery packs the Silverstein S8 enclosure and the battery case must be opened.

Equipment:

1. Two Digital VOMs (fused)

Setup:

1. Separate the nickel cadmium battery connectors and put an ammeter in series with the positive red battery leads.
2. Put an ammeter in series with the negative black battery leads.
3. Attach the remaining two battery connections to there matched connections with two jumpers.

Procedure:

1. Turn the ammeters on.
2. Turn unit on momentarily. The positive side of the battery supply should draw approximately 50 milliamps and the negative side of the battery supply should draw approximately 100 milliamps.

4.1A MONITOR BATTERY METER CALIBRATION:

Equipment:

1. Two VOM
2. Power Supply

Setup:

1. Turn the unit off, and unplug all peripheral equipment from the unit, including the wall mount charger.
2. Remove the four enclosure screws and open the unit. Be careful not to put excessive strain on any wires.
3. Separate the two Molex battery connectors.
4. Adjust the power supply to 16.8 volts then turn the supply off.
5. Attach the positive from the power supply to the red wire on the circuit board side of the Molex connectors.
6. Attach the negative from the power supply to the black wire on the circuit board side of the Molex connectors.

Procedure:

1. Adjust component R35 until both the green and yellow battery LED indicators on the front panel flicker.

2. Turn the supply down to 16.2 volts. The red battery fail indicator should come on at this point. If the fail indicator does not illuminate, adjust component R70 until it just comes on at 16.2 volts.

4.2 STIMULATOR INITIAL POWER UP, STIMULATOR BATTERY METER SET, AND STIMULATOR VOLTAGE REGULATOR CALIBRATION:

Equipment:

1. Digital VOM
2. Power supply

Setup:

1. Set the power supply to 0 volts and turn supply off.
2. Unplug the AA battery pack. Connect power supply to the AA battery pack connector observing polarity.
3. Turn the power supply on.
4. Slowly raise the power supply voltage to 4.75 volts while observing the current draw. The current draw should be approximately 20 milliamps.
5. If the unit is drawing proper current, check the red battery fail indicator. The indicator should just be coming on at 4.75 volts.
6. Adjust component R72 for battery fail at 4.75 volts if necessary.
7. With the power supply at 4.75 volts adjust the stimulator voltage regulator to 3.8 volts. Move the positive volt meter leads to the positive pole of capacitor C16. Move the negative leads to TP7. Adjust R45 until 3.8 volts is displayed on the volt meter.

4.3 STIMULATOR PULSE WIDTH, FREQUENCY, AMPLITUDE AND MOTOR POT OPERATION:

Current intensity refers to the stimulator pulse amplitude in milliamperes. Stimulator pulse amplitude is measured with a 1K resistor across the output of the instrument. The voltage drop across the IK is displayed on the scope. In accordance with Ohm's law, the scope therefore measures pulse amplitude directly in milliamps (1 volt on scope = 1 milliamp).

The GND jack corresponds to the PAD jack and the ACTIVE jack corresponds to the probe tip or active electrode.

The output pulses are negative-going on the scope. See Figure 1 for complete description of stimulator waveform.

Equipment:

1. Oscilloscope
2. IK 1% 1/4W resistor

Setup:

1. Attach a 1K resistor across the output of the stimulator see figure 5 (between ACTIVE and GND).
2. Attach the scope input across the stimulator output see figure 5 (ACTIVE to pos(+), GND to neg (-)).
3. Scope: sweep = .1 milliseconds, sensitivity = 10 millivolts/division, DC coupled, slope at negative (-).

4. Set the Silverstein S8 current intensity display to 0.00 mA.

Procedure:

1. Turn unit on and set the stimulator bias with R62 to 50 microamps (50 millivolt on scope). Change scope sensitivity to 2 volts/division, set the current intensity display to 10 mA and adjust the gain trimpot R59 to 10 milliamps amplitude (10 volts on scope).
2. The bias and gain trimpots are interactive. Repeat step 1 above until both the bias (50 microamps) and the gain (10 milliamps) are correct.
3. Set scope sensitivity to 2 volts/division, sweep to 20 milliseconds/division and align the triggered pulse precisely on the far left grid division marker.
4. Adjust the pulse frequency trimpot R60 to 200 milliseconds (5 pulses/second).
5. Reset the sweep to 0.1 millisecond division and Adjust R46 for a pulse width of 0.2 milliseconds.
6. The motorpot should run smoothly from 0 milliamps to 10 milliamps. If operating improperly check for proper alignment between the motor and the 10 turn potentiometer.

4.4 MONITOR SENSITIVITY:

Equipment:

1. Digital VOM

Setup:

1. Attach the negative lead on the volt meter to monitor Ground TP6, and the positive lead to TP5.

Procedure:

1. Turn the sensitivity Knob to position #1.
2. TP5 should read as follows:

   Position 1 = 35 mv, R27.
   Position 2 = 50 mv, R28.
   Position 3 = 65 mv, R29.
   Position 4 = 100 mv, R30.

4.5 CHEEK-MUSCLE MOVEMENT SENSOR AND INSTRUMENT INPUT CALIBRATION:

Equipment:

1. Silverstein S8 Muscle Movement Sensor
2. Digital VOM

Procedure Part 1 (see figure 9):

1. With the sensor removed from the unit, test the strain gages for proper resistance
2. DO NOT flex the sensor. The two strain gauges should have approximately 350 ohms of resistance to the common pin located in the center of the plug.
3. Attach one lead from the ohmmeter to the center pin on the plug.
4. One at a time, touch the remaining lead from the ohm meter to each of the remaining 3 pins. Two of the leads should equal approximately 350 ohms, one should equal infinite ohms.

Procedure Part 2 (see figure 5):

1. Plug sensor into the unit.
2. Attach the positive leads of the volt meter to TP1, attach the negative leads of the volt meter to TP6 (monitor ground).
3. Turn the unit on. The voltage reading should be between -.5 volts and -4 volts. Do NOT Adjust the offset if the reading is within these limits because each sensor has a slightly different offset. The proper setting allows using many different sensors on each unit. If it is not within tolerance, the sensor is defective or the unit needs calibration.

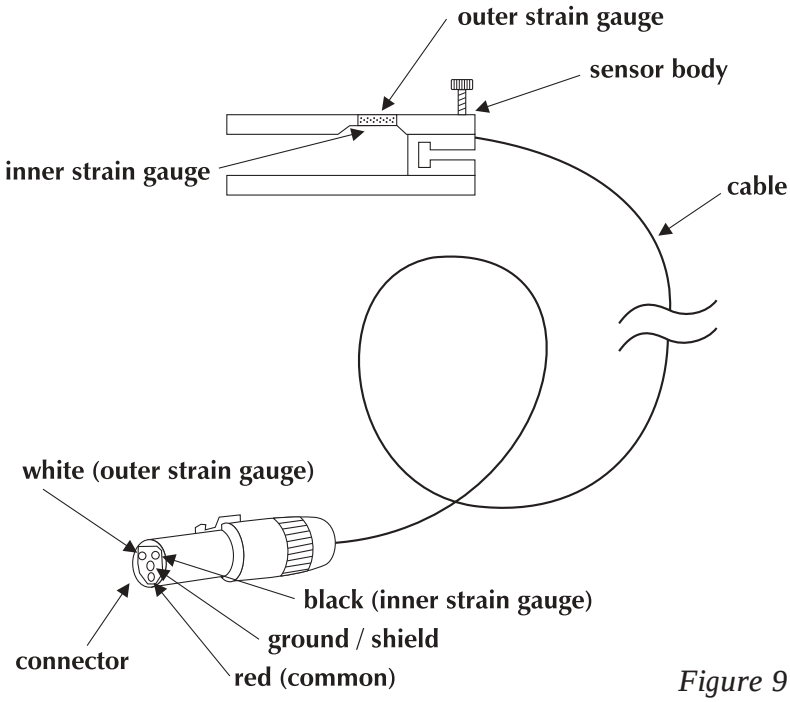


Figure 9

4. WR Medical Electronics suggests sending the complete unit to them if calibration is necessary. If you attempt to adjust the input, use two 350 ohm resistors connected in series that are within 2% of each other, in place of the sensor's strain gages (refer to Figure 8). The "common" point is where the two resistors connect together. This point represents the center connection on the sensor plug where the strain gages meet. Attach the remaining end of each resistor to there respective location. See the schematic for details before attempting this procedure. Adjust R2 until -2 volts is obtained. After calibration repeat step 1, 2, and 3 of section 4.5, part 2. If the offset is still not within specifications, the sensor is defective and must be repaired or replaced.
5. After completing part 2, tap lightly on the sensor to test for alarm output with the sensitivity set at positions 1, 2, 3, and 4.
6. Test the sensor for shorts and open circuits when flexed. The monitor bias with the sensor installed should be checked before testing for sensor shorts and open circuits. This is because the resistance of the strain gages are altered when the blades are flexed a small amount. It takes a short time for the strain gage resistance to stabilize after being flexed. See section 3.5 (part a) for procedure.

4.6 CLOSING THE ENCLOSURE AFTER COMPLETING PRELIMINARY CALIBRATION PROCEDURES:

Procedure:

1. Remove any foreign material from inside the enclosure.
2. Install the enclosure sides/handle assembly on the instrument top panel by sliding it in to place. Check for alignment of the front and rear panels in the groves of the case assembly.
3. Install the case bottom, feet and enclosure screws. Tighten screws down after checking panel alignment.

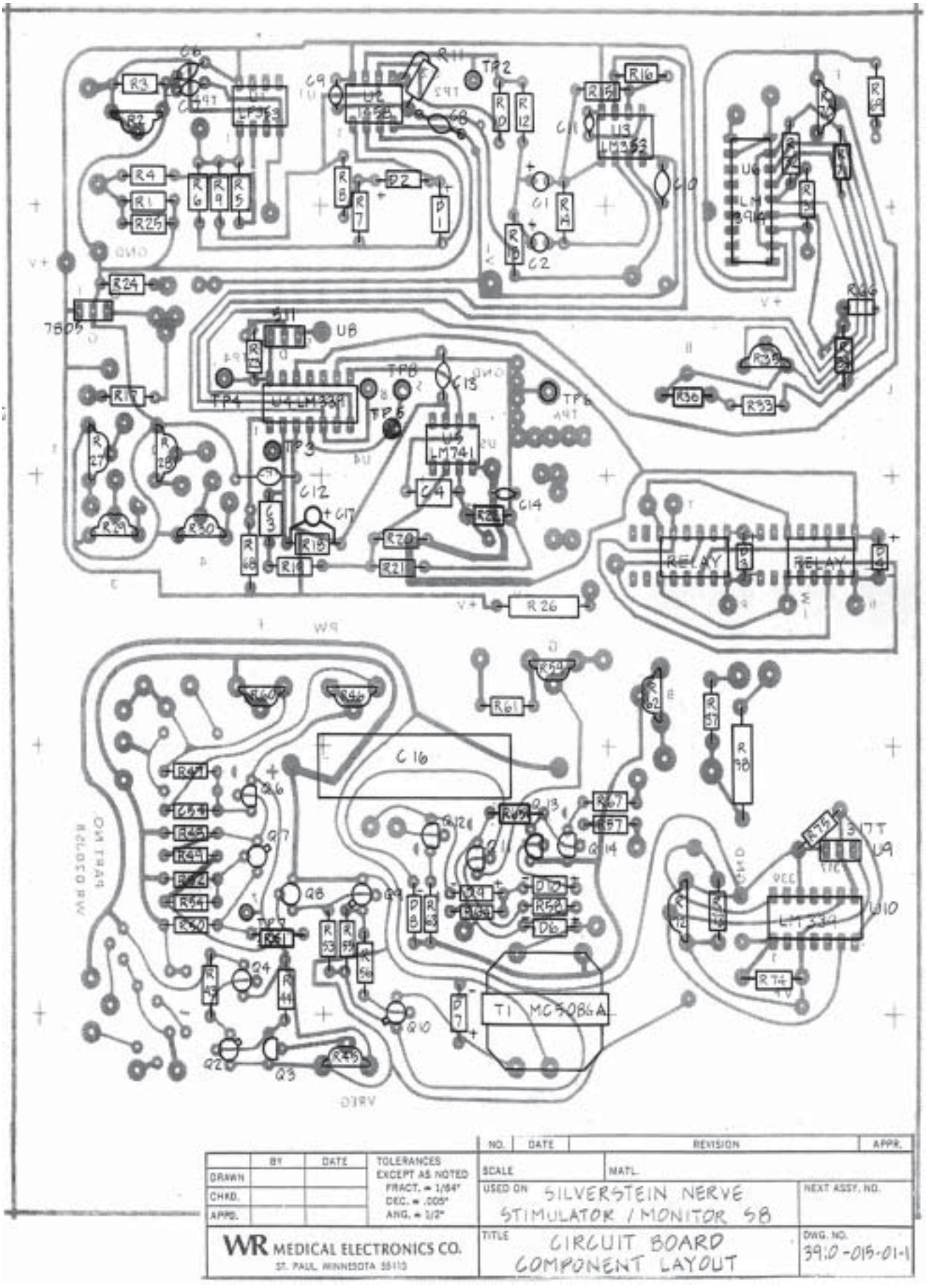
After the unit calibration is complete, and the case is closed, it must then go through complete final checkout procedures, see section 3.

APPENDICES

Board Layout and Schematic

Parts List

Suggested Reading


R3
R2
R4
R1
R25
R6
R9
R5
R24
7805
U8
TP4
U4 LM324
TP8
TP5
TP3
C15
TP6
U5
LM741
C12
C13
C4
C14
R28
R29
R30
R15
R16
R68
R70
R21
R26
RELAY
RELAY
R36
R33
R38
R66
U6
LM
3914
R16
R18
U3
LM363
C11
C10
C1
C2
R10
R12
TP2
R11
C9
C8
U2
R8
R7
D2
D1
U1
LF353
C6
C7
R59
R61
R62
R57
R58
C16
R47
R64
R65
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R54
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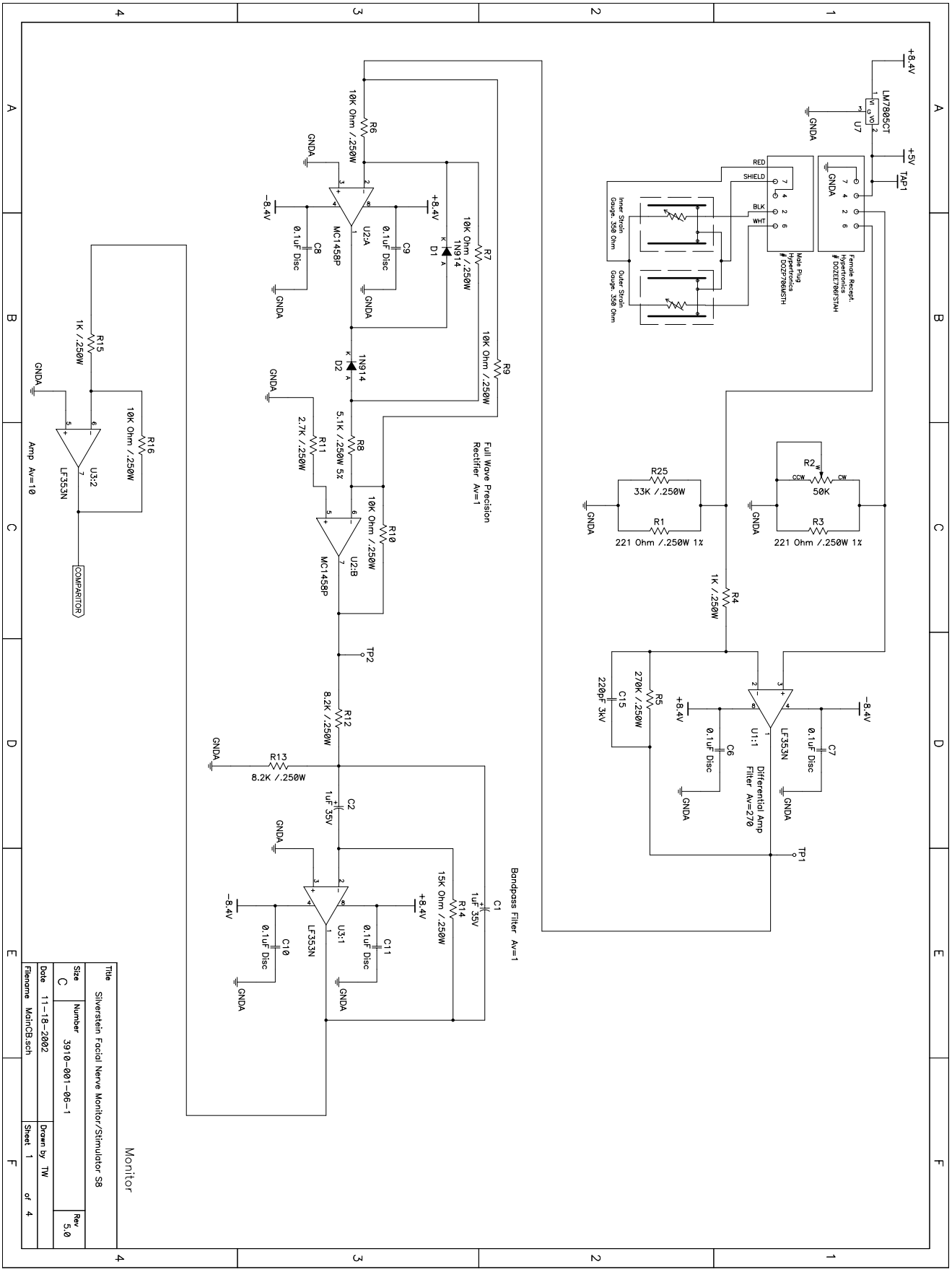
R52
R51
R55
R56
R43
R44
R45
R48
D8
D9
D10
D6
D7
T1 MC5086A
R75
U9
LM339
U10
R74
R72
R73
R71
R12
R13
R14
R17
R27
R31
R32
R35
R37
R39
R40
R41
R42
R46
R60
R61
R62
R57
R58
R59
R63
R64
R65
R66
R67
R68
R69
R70
R71
R72
R73
R74
R75
C16
C15
C14
C13
C12
C11
C10
C9
C8
C7
C6
C5
C4
C3
C2
C1
D1
D2
D6
D7
D8
D9
D10
U1
U2
U3
U4
U5
U6
U8
U9
U10
TP2
TP3
TP4
TP5
TP6
TP7
TP8
SW1
V+
GND
VCC
NO. | DATE | REVISION | APPR.
DRAWN | BY | DATE
CHKD.
APPD.
TOLERANCES EXCEPT AS NOTED
FRACT. ± 1/64"
DEC. ± .005"
ANG. ± 1/2"
SCALE
MATL.
USED ON SILVERSTEIN NERVE STIMULATOR / MONITOR SB
NEXT ASSY. NO.
WR MEDICAL ELECTRONICS CO.
ST. PAUL, MINNESOTA 55110
TITLE CIRCUIT BOARD COMPONENT LAYOUT
DWG. NO. 39.0-015-01-1


+8.4V
LM7805CT
U7
GNDA
+5V
TAP1
RED
SHIELD
BLK
WHT
Female Receptl. Hypertronics # DGZEE7B6TSTAH
Male Plug Hypertronics # DGZP790MSTH
Inner Shield Gauge- 350 Ohm
Outer Shield Gauge- 350 Ohm
R25
33K /.250W
R1
221 Ohm /.250W 1%
R2
CCW
CW
50K
R3
221 Ohm /.250W 1%
R4
1K /.250W
R5
270K /.250W
C15
220pF 3kV
U1:1
LF353N
Differential Amp Filter Av=270
C6
0.1uF Disc
C7
0.1uF Disc
-8.4V
TP1
R6
10K Ohm /.250W
U2:A
MC1458P
C8
0.1uF Disc
C9
0.1uF Disc
D1
1N914
R7
10K Ohm /.250W
R9
10K Ohm /.250W
D2
1N914
R8
5.1K /.250W 5%
R11
2.7K /.250W
R10
10K Ohm /.250W
U2:B
Full Wave Precision Rectifier Av=1
TP2
R12
8.2K /.250W
R13
8.2K /.250W
C2
1uF 35V
Bandpass Filter Av=1
C1
1uF 35V
R14
15K Ohm /.250W
U3:1
LF353N
C10
0.1uF Disc
C11
0.1uF Disc
R15
1K /.250W
R16
10K Ohm /.250W
U3:2
LF353N
Amp Av=10
COMPARITOR
Monitor
Title
Silverstein Facial Nerve Monitor/Stimulator S8
Size
C
Number
3910-001-06-1
Rev
5.0
Date
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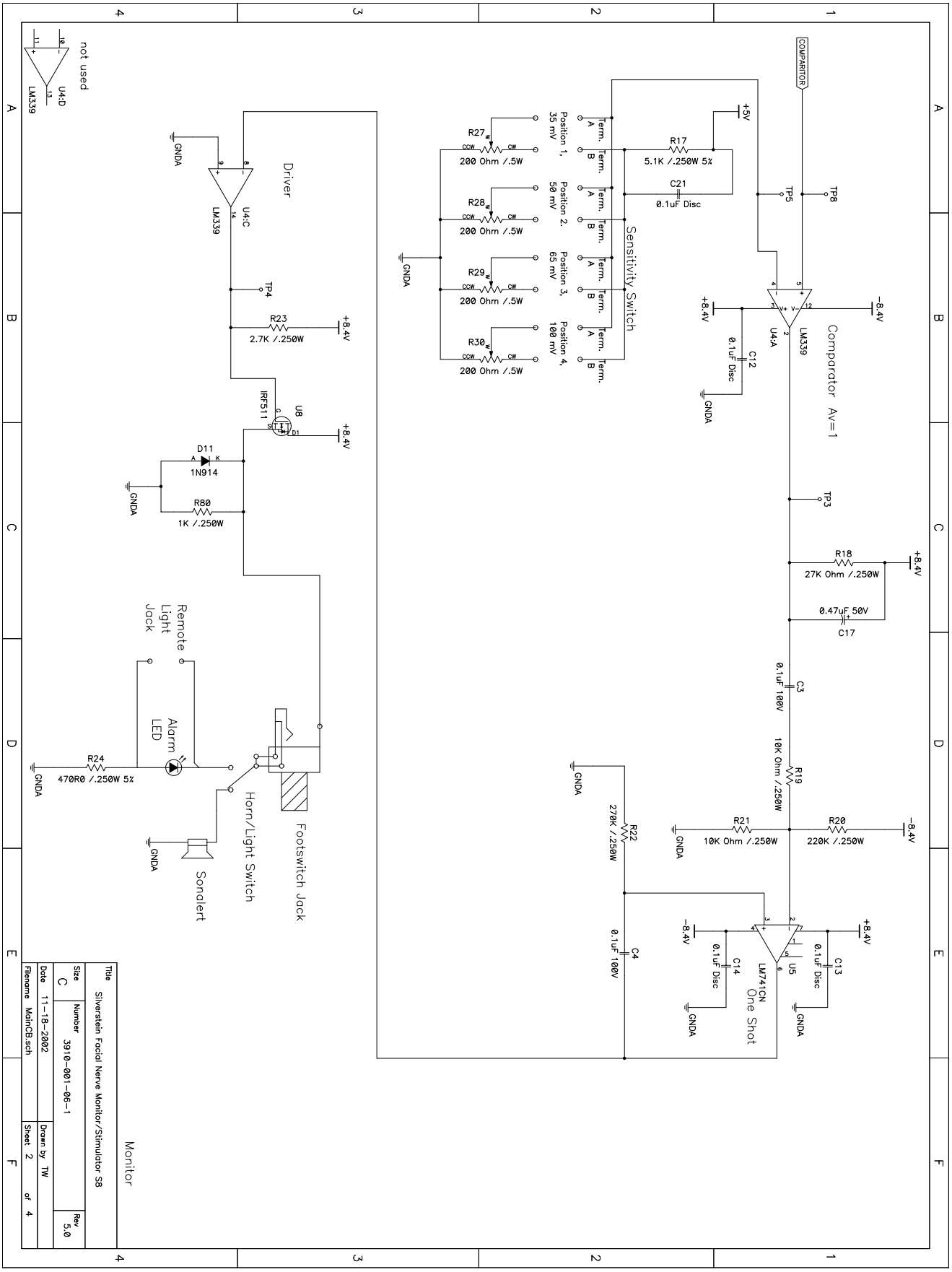
not used
U4:D
LM339
Driver
U4:C
LM339
GNDA
TP4
R23
2.7K /.250W
+8.4V
IRF511
U8
D11
1N914
R80
1K /.250W
Remote Light Jack
Alarm LED
R24
470R0 /.250W 5%
Horn/Light Switch
Footswitch Jack
Sonalert
COMPARITOR
+5V
R17
5.1K /.250W 5%
C21
0.1uF Disc
TP5
TP8
R27
R28
R29
R30
200 Ohm /.5W
Position 1, 35 mV
Position 2. 50 mV
Position 3, 65 mV
Position 4, 100 mV
Term.
Sensitivity Switch
-8.4V
C12
0.1uF Disc
U4:A
LM339
Comparator Av=1
TP3
R18
27K Ohm /.250W
0.47uF 50V
C17
C3
0.1uF 100V
R19
10K Ohm /.250W
R21
10K Ohm /.250W
R20
220K /.250W
R22
270K /.250W
C4
0.1uF 100V
U5
LM741CN
One Shot
C14
0.1uF Disc
C13
0.1uF Disc
Monitor
Title
Silverstein Facial Nerve Monitor/Stimulator S8
Size
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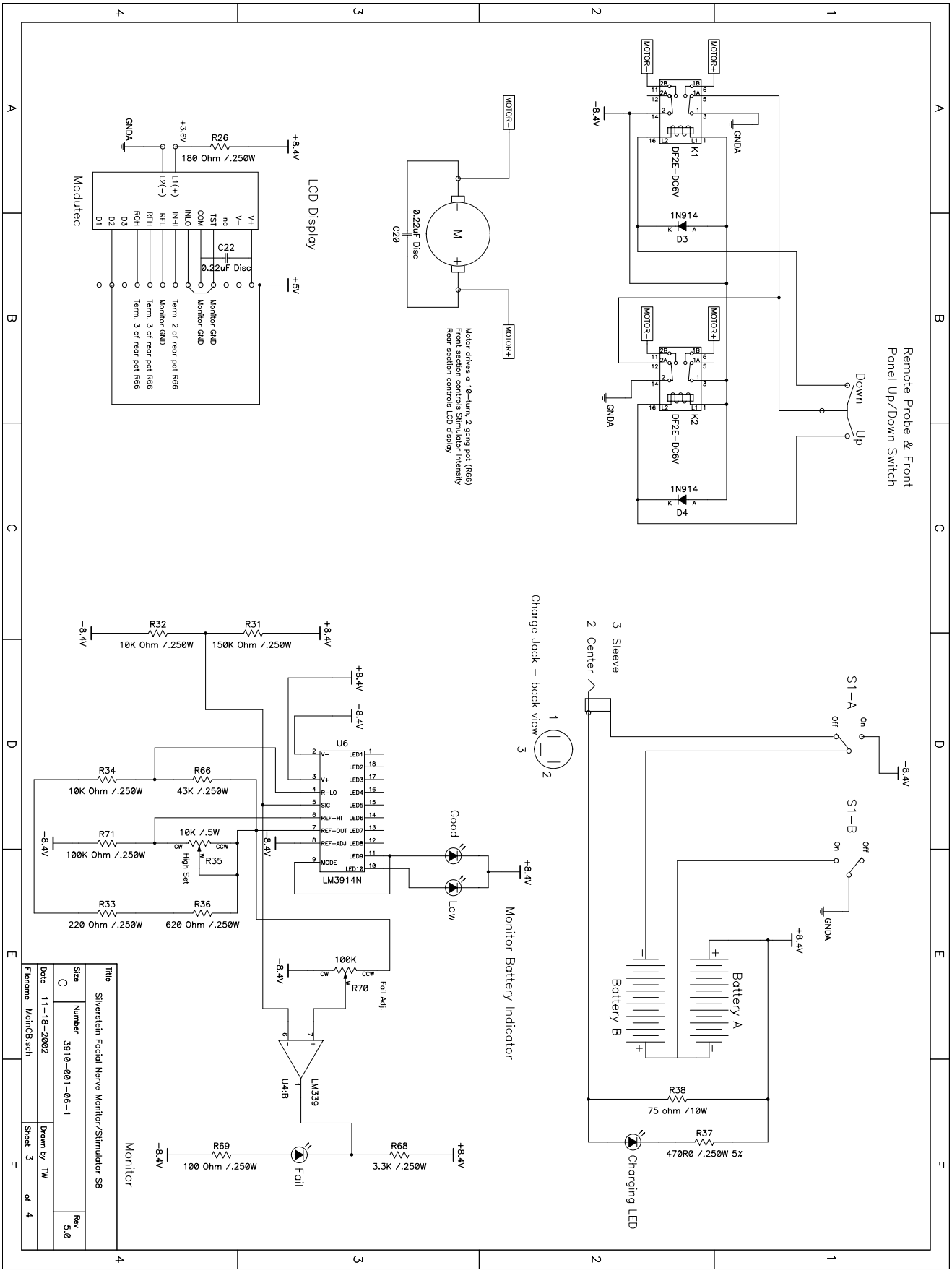
Remote Probe & Front Panel Up/Down Switch
MOTOR-
MOTOR+
DF2E-DC6V
K1
K2
1N914
D3
D4
GNDA
-8.4V
Down
Up
LCD Display
Modutec
+3.6V
+8.4V
+5V
R26
180 Ohm /.250W
C22
0.22uF Disc
L1(+)
L2(-)
V+
V-
nc
TST
COM
INHI
INLO
RFL
RFH
ROH
D1
D2
D3
Monitor GND
Term. 2 of rear pot R66
Term. 3 of rear pot R66
Motor drives a 10-turn, 2 gang pot (R66)
Front section controls Stimulator intensity
Rear section controls LCD display
C20
0.22uF Disc
M
Charge Jack - back view
1
2
3
Sleeve
Center
S1-A
S1-B
On
Off
Battery A
Battery B
R38
75 ohm /10W
R37
470R0 /.250W 5%
Charging LED
R32
10K Ohm /.250W
R31
150K Ohm /.250W
U6
LM3914N
R34
10K Ohm /.250W
R66
43K /.250W
R71
100K Ohm /.250W
10K /.5W
R35
High Set
R33
220 Ohm /.250W
R36
620 Ohm /.250W
Good
Low
Monitor Battery Indicator
100K
R70
Fail Adj.
U4:B
LM339
R69
100 Ohm /.250W
Fail
R68
3.3K /.250W
Monitor
Title
Silverstein Facial Nerve Monitor/Stimulator S8
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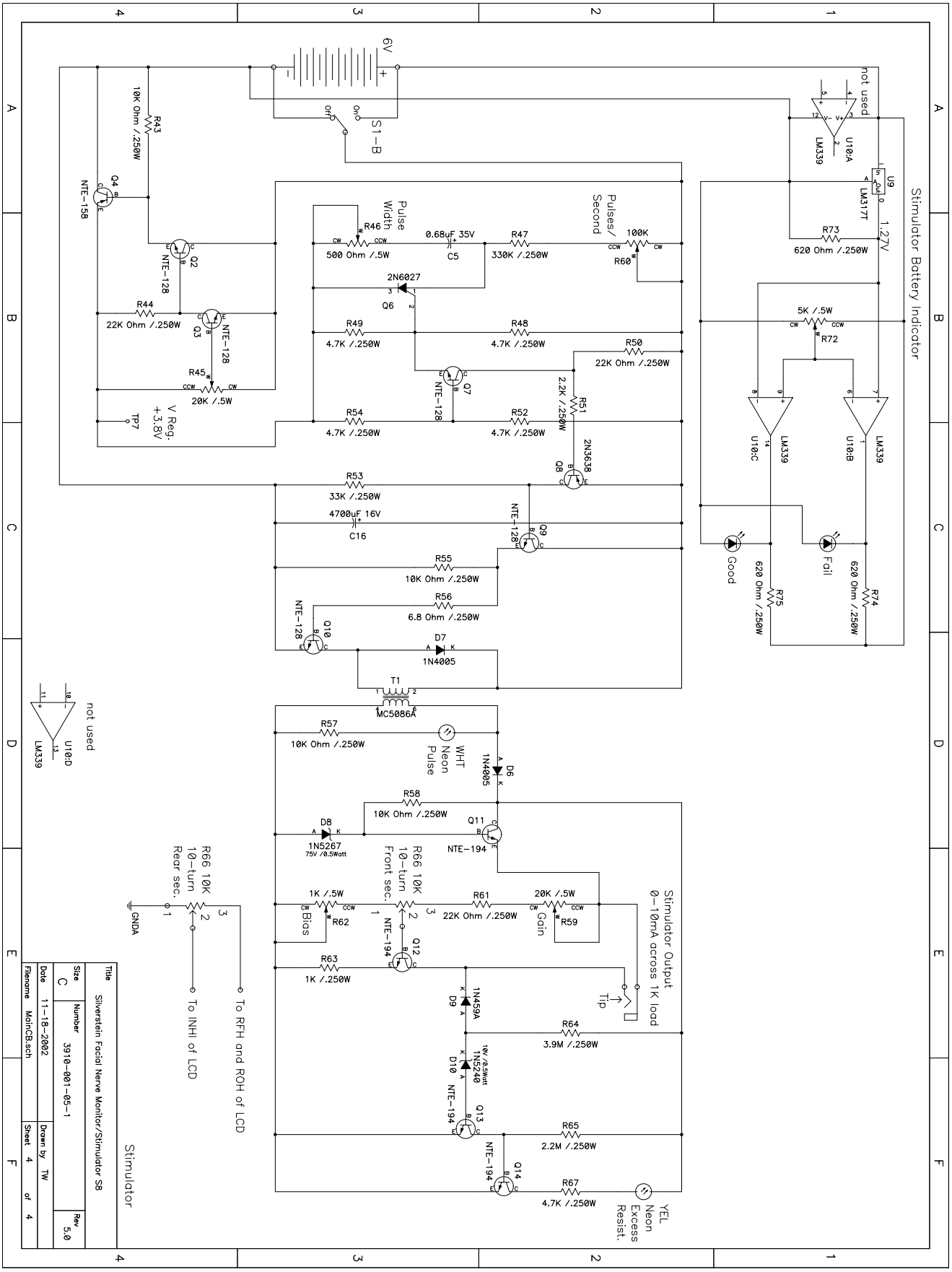
6V
S1-B
not used
U10:A
LM339
U9
LM317T
1.27V
R73
620 Ohm /.250W
Stimulator Battery Indicator
R43
10K Ohm /.250W
Q4
NTE-158
Pulse Width
500 Ohm /.5W
R46
0.68uF 35V
C5
R47
330K /.250W
Pulses/ Second
100K
R60
2N6027
Q6
Q2
NTE-128
R44
22K Ohm /.250W
Q3
NTE-128
R45
20K /.5W
V Reg. +3.8V
TP7
R49
4.7K /.250W
R48
4.7K /.250W
R50
22K Ohm /.250W
Q7
NTE-128
R54
4.7K /.250W
R52
4.7K /.250W
2.2K /.250W
R51
2N3638
Q8
5K /.5W
R72
U10:C
LM339
U10:B
LM339
Good
Fail
R75
620 Ohm /.250W
R74
620 Ohm /.250W
R53
33K /.250W
4700uF 16V
C16
NTE-128
Q9
R55
10K Ohm /.250W
R56
6.8 Ohm /.250W
NTE-128
Q10
D7
1N4005
T1
MC5086A
not used
U10:D
LM339
R57
10K Ohm /.250W
WHT Neon Pulse
D6
1N4005
R58
10K Ohm /.250W
D8
1N5267
75V /0.5Watt
Q11
NTE-194
R66 10K 10-turn Rear sec.
GNDA
R66 10K 10-turn Front sec.
1K /.5W
Bias
R62
R61
22K Ohm /.250W
20K /.5W
Gain
R59
Stimulator Output 0-10mA across 1K load
NTE-194
Q12
R63
1K /.250W
D9
1N4594A
Tip
R64
3.9M /.250W
D10
10V /0.5Watt
1N5240
NTE-194
Q13
R65
2.2M /.250W
NTE-194
Q14
R67
4.7K /.250W
YEL Neon Excess Resist.
To RFH and ROH of LCD
To INHI of LCD
Stimulator
Title
Silverstein Facial Nerve Monitor/Stimulator SB
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Silverstein S8 Materials List

Part #	Component	#	Part #	Component	#
10000	Batt,Alk,AA	4	14146	Conn,Crimp,.10,6 cond,mol	2
10003	Batt,Nicad,8.4V @2200mAH	2	15002	Decal, Wall Mt Chgr S8/Br	1
11000	Batt,hold,Bud,(for dual Nicads)	1	15006	Decal,(Bright Orange)	1
11002	Batt,holder,Pactec w insert	1	15010	Decal,(Ser No.)	1
11015	Case,finished,S8/Brack	1	15014	Decal,Batt Repl,S8	1
11023	Case,panel,front,S8,finished	1	15042	Hdwr,Bracket motorpot	1
11027	Case,panel,rear,S8,finished	1	15048	Hdwr,Cardboard,rect	5
11031	Motorpot,Coupler	1	15049	Hdwr,Cardboard,sq	1
11032	Motorpot,Motor,6V,30RPM	1	15079	Hdwr,Elec,Test Point	8
12005	Cap,Disc,.1uF,12-25V	9	15091	Hdwr,Knob,chrome faced	1
12006	Cap,Disc,.22uF,12v	3	15095	Hdwr,Lock washer,int,#4	4
12008	Cap,Disc,220pF,3000v	1	15098	Hdwr,Nut 4-40 Hex-Keps	2
12010	Cap,Elec,.47uF,50V	1	15103	Hdwr,Nut 8-32 Hex-Keps	2
12011	Cap,Elec,.68uF,35v	1	15121	Hdwr,Screw,Phil pan hd,#4x1/4	16
12017	Cap,Elec,4700uF,6VDC	1	15146	Hdwr,Screw,pan hd,4-40x1/2	2
12021	Cap,Poly,.1uF,100v	2	15149	Hdwr,Screw,pan hd,8-32x1/2	2
12024	Cap, Tant,1 uF,35v	2	15163	Hdwr,Stand-off,PSA, 1/4"	4
12028	Transformer,MC5086A	1	16000	Audio,alarm	1
14004	C.B., Auxport2	1	16005	Display,LCD,Backlit	1
14012	C.B., S8	1	16007	Lamp,LED,green	2
14030	Conn,Header,.10,2 pin	1	16009	Lamp,LED,red	4
14036	Conn,Header,.1,7 pin	1	16011	Lamp,LED,yellow	1
14038	Conn,Header,.10,8 pin	1	16013	Lamp,neon,amber	1
14057	Conn,plug,lDC,.10,2 cond	1	16014	Lamp,neon,clear	1
14063	Conn,plug,lDC,.1,7 cond.	1	17026	Res,1/4w,270 ohm	4
14064	Conn,plug,lDC,.10,8 cond	1	17034	Res,1/4w,O ohm,(jumper)	13
14072	Conn,Jack,4-conductor	1	17038	Res,1/4w,100 ohm,CF	1
14073	Conn,Jack,7 pin,hypertronics	1	17039	Res,1/4w,100K ohm,CF	1
14074	Conn,Jack,BNC	4	17040	Res,1/4w,10K ohm,CF	25
14075	Conn,Jack,Binding Post,Small,Black	1	17042	Res,1/4w,150K ohm,CF	1
14082	Conn,Jack,Phono	1	17043	Res,1/4w,15K ohm,CF	1
14087	Conn,Jack,miniature(Scraft 42A)	1	17046	Res,1/4w,1K ohm,CF	6
14088	Conn,Jack,power	1	17048	Res,1/4w,2.2K ohm,CF	1
14094	Conn,Jack,tip,White	1	17049	Res,1/4w,2.2M ohm,CF	1
14104	Conn,Pin for 6 pin con,mol 0850011	9	17050	Res,1/4w,2.7K ohm,CF	3
14113	Conn,Pin,female,molex 02091143	6	17051	Res,1/4w,220 ohm,CF	2
14114	Conn,Pin,male,lrg tab mol 02092118	2	17052	Res,1/4w,220K ohm,CF	1
14115	Conn,Pin,male,sml tab mol 0209214	4	17053	Res,1/4w,221 ohm,1%	2
14131	Conn,Plug,female,Molex 03092022	3	17054	Res,1/4w,22K ohm,CF	3
14133	Conn,Plug,male,Molex 03091022	3	17057	Res,1/4w,270K ohm,CF	1

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Silverstein S8 Materials List , con't

Part #	Component	#
17058	Res,1/4w,27K ohm,CF	1
17059	Res,1/4w,3.3K ohm,CF	1
17061	Res,1/4w,3.9M ohm,CF	1
17063	Res,1/4w,330K ohm,CF	1
17064	Res,1/4w,33K ohm,CF	2
17066	Res,1/4w,4.7K ohm,CF	5
17067	Res,1/4w,43K ohm,CF	1
17068	Res,1/4w,470 ohm,CF	2
17070	Res,1/4w,47K ohm,CF	4
17071	Res,1/4w,5.1K ohm,CF	2
17074	Res,1/4w,6.8 ohm,CF	1
17075	Res,1/4w,620 ohm,CF	4
17076	Res,1/4w,8.2K ohm,CF	2
17082	Res,10w,75 ohm	1
17085	Res,Pot,10K,10 turn,2 Section	1
17098	Res,Trimpot,25 turn,100K,top adj	7
17103	Res,Trimpot,Piher,100k ohm	3
17104	Res,Trimpat,Piher,10k ohm	2
17107	Res,Trimpot,Piher,1k ohm	1
17108	Res,Trimpot,Piher,200 ohm	4
17109	Res,Trimpot,Piher,20K ohm	2
17110	Res,Trimpot,Piher,500 ohm	1
17111	Res,Trimpot,Piher,5K ohm	1
17131	Res,pot,25turn,20K,top adj	1
20005	Diode, 1N2069A	2
20007	Diode, 1N459A	1
20013	Diode, 1N5240	1
20014	Diode, 1N5267	1
20015	Diode, 1N914	5
20017	IC, 1458,Dual OpAmp	5
20019	IC, 741,0pAmp	2
20020	lC, 7805 Vreg	1
20031	IC, IRF511,Pwr Mosfet	1
20032	IC, LF353,Dual Bifet OpAmp	2
20033	IC, LM317T,pos V-reg	1
20034	IC, LM336Z-2.5V	2
20036	IC, LM339N,Quad Comp	2
20037	IC, LM3914,LED Driver	1
20048	IC, Socket,14 pin	2
20049	IC, Socket,16 pin	2
20054	IC, Socket,18 pin	1
20056	IC, Socket,8 pin	13
20065	Transis, 2N3638	2
20068	Transis, NTE-194	4
20069	Transis, 2N6027	1
20070	Transis, 2N697	4
20074	Transis, GE-53/Phil ECG158	1
20092	Diode,1N4005	2
21010	SW,relay,2 Form C	2
21011	SW,rotary,3P4T	1
21014	SW,toggle,3PDT	1
21015	SW,toggle,SPDT	1
21016	SW,toggle,SPDT,(on)/off/(on)	1
22004	Wire Set, S8	1
23014	Manual pgs, SS opr (3009)	1
23015	Manual pgs, SS serv (3010)	1
23016	Manual pgs, H3 opr (3025)	1
23017	Manual pgs, H3 serv (3024)	1
23018	Manual pgs, SACS kit opr (3029)	1
23019	Manual pgs, Br II serv (3170)	1
23020	Manual pgs, Br II scientific (3169)	1

SUGGESTED READING

The following references will provide excellent reading. Pay particular attention to the articles written by Herbert Silverstein, MD, and view the video provided with the instrument.

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- Gray, Jack A. "Nerve Stimulators and Burns." *Anesthesiology* 42/2:231–232, Feb., 1975.
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- Silverstein, H.; Smouha, E.; and Jones, R.O. "Routine Identification of the Facial Nerve Using Electrical Stimulation During Otological and Neurotological Surgery." *Laryngoscope* 98:1–4, July, 1988.
- Silverstein, Herbert. "Surgery of the Facial Nerve." *J. of Otolaryngol.* 10/6:449–458, 1981.
- Zini, Carlo; Gandolfi, Angelo. "Facial-Nerve and Vocal-Cord Monitoring During Otoneurosurgical Operations." *Otolaryngol. Head Neck Surg.* 113:1291–1293, Dec., 1987.